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Natural Resource Stewardship and Science

Humpback Whale Monitoring in Glacier Bay and Adjacent Waters 2017

Annual Progress Report

Natural Resource Report NPS/GLBA/NRR—2018/1660

ON THE COVER

Abnormally thin 20-year-old male #1299 observed August 2017. Note visible scapula (shoulder blade) and depression behind blowholes.

Image credit: NPS/Janet Neilson

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Annual Progress Report

Natural Resource Report NPS/GLBA/NRR—2018/1660

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This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data. Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

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Contents

Contents (continued)

Page

Figures

Page

Tables

Page

Abstract

Migratory humpback whales (*Megaptera novaeangliae*) use southeastern Alaska as summer feeding habitat, including the waters in and around Glacier Bay National Park and Preserve (GBNPP). This report summarizes GBNPP's humpback whale monitoring program in Glacier Bay and Icy Strait (GB-IS) in 2017, our 33rd consecutive year of consistent data collection in June-August. We documented 128 unique whales, our lowest count since 2003, and effort-corrected counts also revealed steep decreases. By all measures, humpback whale abundance has declined >40% since peaking in 2013. We documented decreases in within-year and between-year site fidelity, with 44% (29 of 66) of whales exhibiting long-term (2004-2013) fidelity to GB-IS interrupting their regular annual return in 2014-2017. This was the fourth consecutive year of calving anomalies, with only two mother/calf pairs in GB-IS (one lost her calf by mid-July), resulting in the second lowest crude birth rate (1.6%) since 1985. We documented no known juveniles (ages 1-4), indicating a possible decline in recruitment, as well as many abnormally thin whales (24%). This was the first year that a reduced vessel speed limit (13 kts) was not warranted in lower GB. The Point Adolphus 'core group' was not sighted and the fate of many group members is unknown. Within Alaska, the long-term, consistent monitoring of humpback whales is limited to GB-IS, making it difficult to determine over what geographic scale these declines in abundance, site fidelity, calving, recruitment, and physical condition are occurring, however there is evidence that declines may be occurring throughout the central North Pacific.

Acknowledgments

The whale sightings, behavioral observations, and enthusiasm from many Park staff, volunteers, researchers, and outfitters are always an essential ingredient in a successful whale monitoring season. We thank Kiana Young for a second summer cheerfully assisting us with data entry and photo analysis. Bruce McDonough's proactive maintenance of the *Sand Lance* kept our research vessel in great running shape, for which we are very grateful. We thank Mayumi Arimitsu (U.S. Geological Survey Alaska Science Center) for continuing to offer her invaluable expertise and infectious enthusiasm for forage fish identification. We thank Emily Fergusson [Alaska Fisheries Science Center/Southeast Coastal Monitoring Project, National Oceanic and Atmospheric Administration (NOAA)] for sharing oceanographic and fish diet data from Icy Strait. Joel Reynolds [National Park Service (NPS) Alaska Regional Office] was very helpful when it came to our statistical analyses and interpretation. Many Park staff and volunteers, external researchers, and visitors reported whale sightings that were recorded and passed along by the Park's Visitor Information Station. For weather reports and whale sightings we thank captains Kevin Lee and Justin Smith (M/V *Baranof Wind)* and Hans Bruning, (M/V *Sea Wolf)*, Dena Matkin (North Gulf Oceanic Society), Todd Bruno (R/V *Capelin*), and the NPS *Serac* crew. This year's work benefitted from sightings from Alaskan Dream Cruises, Forrest Braden (M/V *Endeavor*), Todd Bruno (NPS), Brittney Cannamore (Glacier Bay Sea Kayaks), Marilyn Dahlheim (NOAA), Brian Flory (M/V *LeConte* Master/Alaska Marine Highway System), Mike Greenfelder (Lindblad Expeditions), Jenny Helm (University of Montana), Jim Kearns (M/V *Alaska Dream*), Kierstin Keller, Madison Kosma [University of Alaska Southeast (UAS) Sitka and Alaska Whale Foundation (AWF)], Dena Matkin (North Gulf Oceanic Society), John Moran (NOAA), Mary Beth Moss (NPS), Craig Murdoch (NPS), Heidi Pearson (UAS Juneau), Lewis Sharman (NPS), Rosalind Rolland (New England Aquarium), Steve Schaller (NPS), Tod Sebens (M/V *Taz*), Lisa Szybura, Keith Thompson (M/V *Taurus)*, Stephen and Sybil Van Derhoff, and Jamie Womble (NPS). Thanks to AWF, Suzie Teerlink (Juneau Flukes), and Happywhale (especially Ted Cheeseman and Tory Johnson) for making their humpback whale fluke catalogs available for matching.

We are grateful to Jan Straley and Jennifer Cedarleaf at UAS Sitka for our long and fruitful collaboration. NPS data from 1988 to 1990 were collected by Jan Straley. NPS data from 1985 to 1988 were collected by C. Scott Baker. This year's study was carried out under NOAA Fisheries Permit #15844-02. Thanks to NOAA staff Kate Savage, Sadie Wright, Mandy Migura, Aleria Jensen, and Ed Lyman for investigating, compiling and sharing data on humpback whale strandings and entanglements in Alaska. We thank Chris Sergeant and Suzie Teerlink for reviewing this report and providing valuable comments and feedback.

Introduction

This report summarizes the findings of Glacier Bay National Park and Preserve's (GBNPP) humpback whale (*Megaptera novaeangliae*) monitoring program during the summer of 2017, the 33rd consecutive year of consistent data collection in Glacier Bay and Icy Strait, Alaska. The initial impetus for this program stemmed from concern in the late 1970s that increased vessel traffic in Glacier Bay may have caused a large proportion of the local whale population to abandon the bay (Jurasz and Palmer 1981). Beginning in 1973, humpback whales were listed as endangered under the U.S. Endangered Species Act [National Oceanic and Atmospheric Administration (NOAA) 2016], which afforded them increased federal protection and conservation concern. In addition, the National Park Service (NPS) is mandated to ensure that park management decisions do not negatively impact wildlife such as humpback whales [NPS Organic Act, 54 U.S. Code 100101(a)]. Therefore, each summer since 1985, Park biologists have documented the number of individual humpback whales in Glacier Bay and Icy Strait, as well as their residence times, spatial and temporal distribution, reproductive parameters, and feeding behavior. These data are used as an index to monitor long-term trends in the population's abundance, distribution, and reproduction (Gabriele *et al.* 2017). Long-term and consistent data collection in longitudinal studies is extremely rare and valuable in understanding the population parameters and recovery of an endangered species. The ongoing, systematic study of humpback whales in Glacier Bay-Icy Strait by GBNPP now constitutes one of the longest and most complete time-series of data on a living baleen whale population with documented individual humpback whale sighting histories of up to 45 years (Jurasz and Palmer 1981; Perry *et al.* 1990; Gabriele *et al.* 2017).

Photographic identification, life history, and genetic data from this study are shared with other researchers studying humpback whales (*e.g.*, Mizroch *et al.* 2004; Herman *et al.* 2009; Barlow *et al.* 2011; Hendrix *et al.* 2012; Baker *et al.* 2013; Pierszalowski *et al.* 2016). Beginning in 2011, Park biologists began collaborating with the National Marine Fisheries Service Alaska Region's Office of Protected Resources to produce whale sighting maps to provide timely updates to cruise ship captains on shifting whale distribution in GB-IS to help ship captains prevent whale-vessel collisions and disturbance. In addition, Park biologists use whale distribution data on a daily basis to make recommendations regarding when and where GBNPP 'whale waters' vessel course and speed restrictions should be implemented in Glacier Bay to reduce whale disturbance and collision risk.

Most humpback whales that feed in southeastern Alaska (SEAK) in the summer spend the winter breeding season in the Hawaiian Islands, although a small proportion (about 6%) winters in Mexico and some whales have visited both Hawaii and Mexico (Baker *et al.* 1986; Perry *et al.* 1990; Calambokidis *et al.* 1997; Calambokidis *et al.* 2008; Baker *et al.* 2013; Wade *et al.* 2016). In September 2016, NOAA reclassified humpback whales under the Endangered Species Act (ESA) into 14 distinct population segments (DPSs) worldwide, designated by breeding areas. Prior to this, all humpback whales worldwide were listed as 'endangered' under the ESA. Upon reclassifying, NMFS determined that the Hawaii DPS (along with nine other DPSs) no longer warranted listing under the ESA. However, the Mexico DPS was listed as 'threatened' (NOAA 2016). The most recent population estimate for SEAK and northern British Columbia was 6,137 humpback whales in 2004-

2006 (CV = 0.070) (Wade *et al.* 2016). For northern SEAK alone, the most recent estimate was 1,585 humpback whales in 2008 (95% central probability interval: 1455, 1644) (Hendrix *et al.* 2012). From 1985 through 2015, the number of unique whales documented annually in GB-IS ranged from 41 to 240 whales, which closely matches population size estimates for this area through 2009 derived from capture-recapture models (Saracco *et al.* 2013). Humpback whales that summer in SEAK exhibit strong maternally-directed site fidelity that has driven population growth over time (Baker *et al.* 1990; Straley 1994; Baker *et al.* 2013; Pierszalowski *et al.* 2016). In the study area, the population increased annually by an estimated 5.1% (95% CI = -1.3%, 11.9%) from 1985-2014 and exhibited an accelerated rate of growth from 2002-2011 (11.1%/yr, 95% CI = 4.1%, 18.6%) (Gabriele *et al.* 2017). However, beginning in 2014 there was a marked decline in the number of whales in Glacier Bay and Icy Strait, particularly in Icy Strait (Neilson and Gabriele 2016).

Humpback whale movement throughout SEAK is presumed to be linked with prey availability, which likely influences the number of whales in the study area (Baker *et al.* 1990; Krieger 1990; Straley 1994; Straley *et al.* 1995). Whales in GB-IS typically feed alone or in pairs (Gabriele *et al.* 2017), primarily on small schooling fishes such as capelin (*Mallotus villosus*), juvenile walleye pollock (*Gadus chalcogrammus*), Pacific sand lance (*Ammodytes personatus*), and Pacific herring (*Clupea pallasii*) (Wing and Krieger 1983; Krieger and Wing 1984, 1986; NPS unpublished data). While forage fish vary in their average lipid content by species, age, year, and geographic location, adult herring, capelin, and sand lance represent some of the highest lipid forage fishes in the Gulf of Alaska (~23% - ~27% lipid), while juvenile walleye pollock represent a relatively low-lipid forage fish (~7% lipid) (Anthony *et al.* 2000). A notable exception to the smaller group sizes typically seen in GB-IS is the large (e.g., 10-12 or more whales), stable, coordinated 'core group' that commonly feeds at Point Adolphus in Icy Strait, although in recent years the group's size and persistence during the summer have declined (Neilson *et al.* 2014, 2015, 2017; Neilson and Gabriele 2016). In addition, large aggregations of whales have occasionally gathered to feed at various other locations in GB-IS, however, these aggregations are less consistent than the Point Adolphus core group (NPS unpublished data).

Methods

The methods used for this annual monitoring program have been described in previous reports and publications (*e.g.*, Gabriele *et al.* 2017). The primary techniques have not changed significantly since 1985, allowing for comparison of data among years. The specific methods used in 2017 are outlined below. In addition, from July 24 - August 4, 2017 we used these same methods to participate in the second year of a collaborative study of humpback whales in northern SEAK called "Survey of Population Level Indices for Southeast Alaska Humpbacks" (SPLISH) (Moran *et al.* 2017).

Vessel Surveys

We conducted vessel surveys in Glacier Bay and Icy Strait from April 11 through October 30, 2017. One to two observers searched for, observed, and photographed humpback whales from the *Sand Lance*, a 5.8-meter motorboat based in Bartlett Cove and equipped with a four-stroke Mercury 150 HP outboard engine.

The study area (1,668 sq. km) included most of Glacier Bay and Icy Strait (Figure 1) with a primary survey area (770 sq. km) covering the main body of Glacier Bay (roughly defined by four corners: Point Gustavus, Point Carolus, Geikie Inlet, and Garforth Island) and central Icy Strait (roughly defined by four corners: Point Gustavus, Point Carolus, Mud Bay, and Pinta Cove). Between June 1 and August 31, we surveyed the primary survey area in Glacier Bay 3-4 days per week. We surveyed the East Arm of Glacier Bay (generally only as far as the mouth of Adams Inlet) and the West Arm of Glacier Bay (generally only as far as Russell Island) infrequently. We did not conduct surveys in any Park designated non-motorized waters, although we receive occasional reports of whales in these areas. All indications are that the whales in non-motorized waters also use the motorized waters in Glacier Bay and are thus documented at least once at current levels of survey effort; at a minimum these whales must travel through motorized waters to reach non-motorized areas. We surveyed Icy Strait approximately once per week, with the greatest survey effort focused in the primary survey area. Glacier Bay is the main area of NPS management concern with regard to whales, but descriptions of the whales' use of Icy Strait provide essential context for the Glacier Bay results because whales frequently move between these areas and because Park waters include portions of Icy Strait.

We use a mixed approach in which we target 'hotspots' where whale sightings have been reported or are known to frequent, while also surveying outlying areas where whales may or may not be present. Survey effort is only systematic to the extent that we aim to survey a particular portion of the study area on a given day and we typically did not conduct surveys in the same area on consecutive days. However, where the whales are, and how many there are, dictates where the survey takes place and how much area we cover each day. We strive to maintain a comparable level of survey effort each year but it inevitably fluctuates as a result of inter-annual variability in factors beyond our control such as weather, availability of staff, and unexpected events (*e.g.*, mechanical difficulties and marine mammal strandings that temporarily re-focus our duties). In addition, when whale abundance is low in an area, it takes less time to survey the area due to the lower number of encounters.

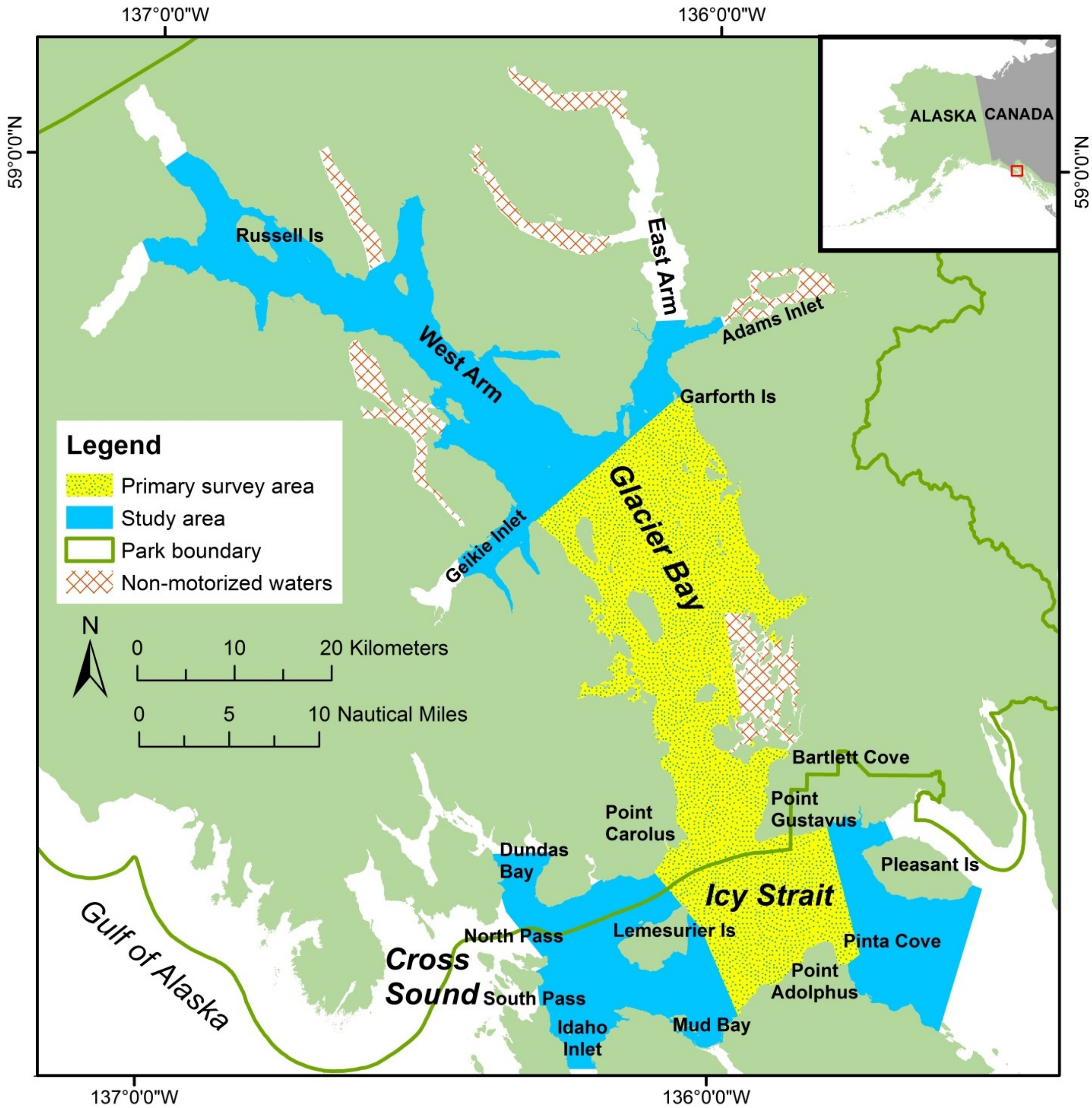

Figure 1. Study area in Glacier Bay and Icy Strait showing primary survey area and non-motorized waters.

The primary intent of the survey protocol is to photographically identify as many whales as possible in the study area between June 1 and August 31 in a manner that is comparable between years for monitoring humpback whale population trends. Gathering life history data on individual whales is another main goal of the study, made possible by the whales' strong site-fidelity to the study area and the high level of effort with which we cover the study area. Another key objective of the study is to inform park management about whale distribution in an effort to manage and mitigate vessel impacts to whales (*e.g.*, whale waters), thus our effort favors areas where vessel management is a concern. We limit our observations to good to fair ocean and visibility conditions [*e.g.*, in most cases, Beaufort ≤ 3, seas < 0.6 m (2 ft) and visibility > 0.8 km (0.5 mi)] and we make periodic stops to scan with 10x40 binoculars and listen for blows to keep our detection rate of whales high. This survey approach, combined with a high level of effort, approximates a census that identifies most of the whales in the study area in a given summer. In a recent study, capture-recapture statistical techniques were applied to GBNPP humpback whale monitoring data collected from 1985-2009 and revealed that our annual whale counts equal about 90% of the non-calf whales estimated for the same study area (Saracco *et al.* 2013).

We defined 'survey hours' as the time we spent on the water in the study area each day (*i.e.*, from the time we departed the dock until the time we returned). This metric has been used since 1985. Beginning in 2005, we began recording 'effort hours' as the time we spent actively searching for whales each day (*i.e.*, not including transit time to/from the portion of the study area that was the day's focus). We also re-defined a survey 'day' from any day with survey hours in Glacier Bay or Icy Strait (1985-2004) (*i.e.*, some Glacier Bay 'days' were solely transits to/from Icy Strait) to only those days with effort hours in Glacier Bay or Icy Strait (2005-present). We count days in which there was effort in both Glacier Bay and Icy Strait as one Glacier Bay day and one Icy Strait day.

We defined a pod of whales as one or more whales within 2-3 body lengths of each other, surfacing and diving in unison (Baker 1985; Clapham 1993). We defined a shoal as a group of whales composed of subgroups that were within 2-3 body lengths of each other that were not necessarily surfacing and diving in unison and in which associations between individuals were fluid and ephemeral. Upon locating a pod or a shoal, we recorded the latitude and longitude coordinates of their initial location. We used a GPS-enabled iPad with Tap Forms software version 4.0.7 (Tap Zapp Software, Inc., Calgary, Canada), combined with custom datasheets, to record field data pertaining to the pod or shoal, including the initial location, number of whales, their behavior (feed, travel, surface active, rest, sleep, unknown), sketches of the markings on their tail flukes and dorsal fin, photographs taken, whale identity (if known), water depth, sea surface temperature, and any prey patches observed on the depth sounder. If the whales were feeding, we categorized their feeding behavior as subsurface, vertical lunge, lateral lunge, bubblenet, other bubble, flick, or unknown (Jurasz and Jurasz 1979).

Individual Identification

The ventral surface of each whale's flukes has a distinct, stable black and white pigment pattern that allows for individual identification (Jurasz and Palmer 1981; Katona *et al.* 1979). For some whales, the shape and scarification of the dorsal fin also serve as unique identifiers (Blackmer *et al.* 2000). We took photographs of each whale's flukes and dorsal fin with a Nikon D7200 digital camera equipped with a 100-300 mm zoom lens. On August 29 we began using an 80-400 mm zoom lens. We compared fluke and dorsal fin photographs to previous NPS photographs and to photographs of other humpback whales from SEAK [Alaska Whale Foundation (AWF), Juneau Flukes, and University of Alaska Southeast (UAS) unpublished data; www.happywhale.com] to determine the identity and past sighting history of each whale.

We referred to many whales by a permanent identification number common to the combined catalogs of GBNPP and University of Alaska Southeast researcher Jan Straley (http://alaskahumpbacks.org/flukeIDcatalog.html). We also referred to those whales first photo-identified by Jurasz and Palmer (1981) by their nicknames. We only assigned calves a permanent identification number if we obtained at least one adequate photograph of the calf's flukes and the calf was sighted on more than one day. For calves that did not meet these criteria, we assigned a temporary unique identifier in the format "XXXX_calf_YYYY," where XXXX is the mother's identification number, and YYYY is the four-digit year (*e.g.*, 2024_calf_2017). For non-calf whales that had not been previously identified in Glacier Bay and Icy Strait, we assigned temporary alphanumeric identification numbers. We replaced these temporary numbers with permanent identification numbers if we identified the whale on more than one day or if the whale was identified elsewhere by another researcher. Photographic and sighting data were added to a relational database containing Glacier Bay and Icy Strait whale sighting histories from 1977 to 2017. We also selected, printed, and catalogued the best 2017 identification photograph (flukes or dorsal fin) of each individual.

Whale Counts

We examined the 2017 season's photographs to determine the number of unique whales we observed. We counted the number of unique whales that we sighted in Glacier Bay, Icy Strait, and the combined GB-IS area for the dedicated monitoring period (June 1 - August 31). We used the "line drawn between Point Gustavus and Point Carolus" [Title 36 Code of Federal Regulations (CFR) Subpart N, 13.1102] to separate Glacier Bay and Icy Strait and assigned sightings north of the line to Glacier Bay and sightings south of the line to Icy Strait. This line may be biologically arbitrary but it is relevant for GBNPP regulatory purposes. From 2005-2017 we tracked unique whales/survey hour and unique whales/effort hour to correct for fluctuations in survey effort. Unique whales/effort hour is our preferred metric for assessing annual trends in whale abundance because it includes only the time spent actively searching for whales.

Environmental Conditions

Since 2016 we have consulted the results of the Southeast Coastal Monitoring (SECM) project in interpreting our whale counts. SECM is an annual systematic survey conducted by NOAA that includes a transect in Icy Strait that roughly follows the eastern boundary of our study area. The SECM project has collected oceanographic and zooplankton data along this transect since 1997 (Fergusson *et al.* 2017b) that provides biophysical context for our whale observations. The annual Icy Strait Temperature Index (ISTI) is the average top-20 m integrated water column temperature along the Icy Strait transect (n = 4 stations) and a transect at the junction of Icy Strait/Chatham Strait (n = 4 stations), measured monthly May-August (E. Fergusson, pers. comm.).

Physical Condition

We do not systematically monitor whales' body conditions, however we opportunistically noted when individual whales appeared to be abnormally thin (*e.g.*, scapulae protruding and/or noticeable postcranial depression; after Bradford *et al.* 2012). We also opportunistically documented whales with unusual-looking skin and/or infestations of external parasites (*Cyamus* sp.) that may indicate compromised health (*e.g.*, Osmond and Kaufman 1998).

Site Fidelity

We determined the number of whales that were 'resident' in the study area in 2017. We designated a whale as resident if it was photographically identified more than once in Glacier Bay and/or Icy Strait over a span of 20 or more days between June 1 - August 31 (after Baker 1986). Sighting data indicate that many whales remain in the study area (*e.g.*, see Appendix in Neilson *et al*. 2014) but in some cases, an individual could leave Glacier Bay or Icy Strait in the interval between our sightings, then return, and be counted as a resident in the study area as long as 20 or more days had elapsed between two or more GB-IS sightings.

After noticing that many individual whales that had historically returned to the study area every summer interrupted their long-term site fidelity beginning in 2014, for the second year in a row we attempted to quantify changes in between-year site fidelity (Neilson *et al.* 2017). This year we adopted a new approach in our continuing effort to describe and quantify these changes. We defined 'regularly sighted' whales as individuals that had been documented in the study area between June 1 and August 31 for 10 consecutive years from 2004-2013.

We compared the sex ratio of regularly sighted whales with the sex ratio of all whales documented in GB-IS from 2004-2013. For the latter, we only included whales known to have been alive by 2004 (based on prior sightings anywhere in SEAK) or whales documented as a calf in GB-IS in 2004. This resulted in a 2x2 contingency table where all whales of known sex that had been documented in GB-IS from 2004-2013 were classified as either regularly sighted (documented all 10 years) or not regularly sighted (documented <10 years). Next, we examined regularly sighted whales' sighting histories from 2014-2017 to determine how many exhibited breaks in their fidelity to the study area. This resulted in a 2x2 contingency table where regularly sighted whales (2004-2013) of known sex were classified as either continuing to be regular in 2014-2017 or interrupting their return for one or more years in 2014-2017.

We used Fisher's exact probability tests to test for significant differences in sex ratios between groups because this test is well-suited for analyzing categorical data in 2x2 contingency tables.

Reproduction and Juvenile Survival

We monitored the reproductive histories of individual females and documented the return and recruitment of their offspring into the population. We defined the following age classes for whales whose birth year was known based on photo-identification records: calves (less than one year old), juveniles (age 1-4 years, as determined by prior sighting history), and adults (age $\geq$ 5 years) (Chittleborough 1959). We calculated crude birth rate as an index of reproduction by dividing the number of calves by the total whale count from June 1 - August 31.

Tissue Samples

We opportunistically collected sloughed skin on the sea surface with a small dip-net when whales breached or performed other 'surface active' behavior (*e.g.*, breaches, tail slaps, etc.). We stored these sloughed skin samples in plastic vials filled with dry table salt (NaCl). We archived one-third of each skin sample at GBNPP (in dry salt) and sent one-third to be archived (frozen at -80° F) at the National Marine Fisheries Service Southwest Fisheries Science Center where they are available on request to other scientists studying a variety of topics. The remaining one-third of the sample was provided to the Cetacean Conservation and Genomics Laboratory at Oregon State University for use in our long-term collaboration examining humpback whale population structure in southeastern Alaska.

Feeding Behavior and Prey Identification

We opportunistically documented any unusual humpback whale feeding behavior (*i.e.*, different from typical subsurface, vertical lunge, lateral lunge, bubblenet, other bubble, or flick) that we observed in the study area.

We recorded instances when we observed probable whale prey such as small schooling fish in the vicinity of whales. In addition, we collected anecdotal reports of whale prey in the study area. We used field guides (Smith and Johnson 1977; Pearse *et al.* 1987; Hart 1988; Mecklenburg *et al.* 2002; Johnson *et al.* 2015) and/or provided high resolution photographs to forage fish identification expert Mayumi Arimitsu (U.S. Geological Survey Alaska Science Center) to taxonomically identify sample prey items that we observed and/or collected opportunistically using a dip-net.

To augment our opportunistic whale prey observations, we consulted SECM's annual stomach content analyses from larger pelagic fish (primarily salmon) in Icy Strait that identify the number and species of forage fish and zooplankton consumed. In the absence of quantitative annual forage fish monitoring in our study area, these data offer valuable insight into recent trends in forage fish availability and species composition in Icy Strait.

Whale/Human Interactions

We summarized the location and duration of GBNPP whale waters in 2017. 'Whale waters' are defined by NPS regulation as "any portion of Glacier Bay, designated by the superintendent, having a high probability of whale occupancy, based upon recent sighting and/or past patterns of occurrence" (Title 36 CFR Subpart N, 13.1102). The whale observations from this study are used to make recommendations to the GBNPP superintendent on where and when whale waters should be implemented. Vessel course and speed restrictions have long been used to reduce whale disturbance and collision risk in Glacier Bay whale waters (Title 36 CFR Subpart N, 13.1174 and 13.1176). Course restrictions require transiting vessels over 5.5 m (18 ft) to remain at least 1.9 km (1 nautical mile) from shore, or mid-channel in areas too narrow to maintain this distance, to avoid the near shore areas most often used by feeding whales. However, because whales are not limited to near shore areas and are often present mid-channel, vessel speed restrictions are an additional mitigation employed to protect whales in park waters.

We summarized whale/human interactions (including vessel collisions, dead whales, and entanglements) in the study area and elsewhere in Alaska in 2017, based on our observations and those of other NPS staff, stranding data compiled by the NOAA Alaska Region Office of Protected Resources, the media, and via anecdotal observations from the public. In addition, we opportunistically documented disturbance of whales by vessels and aircraft in the study area. While our reporting is likely not comprehensive because under-reporting is known to occur, we attempted to characterize the number and types of whale/human interactions using the best available information.

Results and Discussion

Vessel Surveys

Our survey hours (362 h) and effort hours (289 h) in the overall study area were average compared to 2005-2016 (359.3 h and 284.4 h, respectively) (Table 1). Compared with this same period, our effort in Glacier Bay (210 h) was above average (187 h) while our effort in Icy Strait (79 h) was below average (98 h). Our below average survey effort in Icy Strait in 2017 in part reflects relatively lower whale numbers there compared with 2005-2016 (see Whale Counts, below). In addition, from 2005-2013, anomalously high numbers of whales around Point Carolus just outside Glacier Bay in Icy Strait likely inflated our Icy Strait effort. Since 2014, Point Carolus ceased being a whale hotspot (Neilson *et al.* 2015). Table 2 shows monthly and annual number of survey days in Glacier Bay and Icy Strait, 1985-2017.

Whale Counts

Between June 1 and August 31, 2017, we documented 128 different humpback whales in the study area (Table 3, Figure 2, Figure 3). This count represents 22% fewer individuals than in 2016 (n = 165) and our lowest annual whale count since 2003. We documented 24 individual whales (19%) in both Glacier Bay and Icy Strait, demonstrating the strong connectivity between these two areas. The number of individuals in Glacier Bay (n = 85) was 27% lower than in 2016 (n = 117), while the number in Icy Strait (n = 67) was 33% lower than in 2016 (n = 100). These declines could be explained by a shift in distribution to other areas in SEAK and/or an increase in mortality (see below).

Comparing effort-corrected counts rather than the number of individuals reveals even steeper declines in whale abundance in 2017 compared with 2016 in the study area as a whole (-37%), Glacier Bay (-46%), and Icy Strait (-36%) (Figure 3, Figure 4, Figure 5). Following the abrupt decline in abundance in 2014 that came after a long-term pattern of population growth, the GB-IS population appeared to be rebounding in 2015-2016 based on effort-corrected counts (Neilson *et al.* 2017). However, the 2017 effort-corrected counts in Glacier Bay (0.40 whales/effort h), Icy Strait (0.85 whales/effort h), and the overall study area (0.44 whales/effort h) are record lows since we began logging effort hours in 2005. By comparison, at the peak of whale abundance in 2011-2013, we observed 0.87 whales/effort h in Glacier Bay (Figure 4), 2.02 whales/effort h in Icy Strait (Figure 5), and 0.78 whales/effort h in the overall study area (Figure 3).

Outside of the regular June through August monitoring period, we documented an additional six whales in the study area, for a grand total of 134 unique whales in 2017. We observed three of these additional whales on various dates in May and the other three on a single day (October 30) near Pleasant Island in Icy Strait.

We considered three whales (one in Glacier Bay and two in Icy Strait) to be ‘new’ because we had not sighted them previously in the study area. All appeared to be adults based on their body size. One of the whales had been documented previously in SEAK but the other two had no prior recorded sightings.

Table 1. Annual number of survey hours and effort hours in Glacier Bay, Icy Strait, and the combined area, June 1 - August 31, 1985-2017. The dashed line highlights a change in the way we calculated survey effort beginning in 2005 (see Neilson and Gabriele 2007). Survey hours are not available for 1986 or 1987. For 2005-2017, survey hours are only available for the combined area (Glacier Bay-Icy Strait). Effort hours are not available prior to 2005.

	No. survey hours			No. effort hours		
Year	**GB**	**IS**	**GB-IS**	**GB**	**IS**	**GB-IS**
1985	234	92	326	–	–	–
1986	–	–	–	–	–	–
1987	–	–	–	–	–	–
1988	199	108	307	–	–	–
1989	231	123	354	–	–	–
1990	215	115	330	–	–	–
1991	256	100	356	–	–	–
1992	248	71	319	–	–	–
1993	192	62	254	–	–	–
1994	169	92	261	–	–	–
1995	167	90	258	–	–	–
1996	259	116	374	–	–	–
1997	327	90	417	–	–	–
1998	344	64	408	–	–	–
1999	318	64	382	–	–	–
2000	321	84	405	–	–	–
2001	236	76	312	–	–	–
2002	297	68	365	–	–	–
2003	283	101	384	–	–	–
2004	373	74	447	–	–	–
2005	–	–	357	216	56	272
2006	–	–	356	197	85	282
2007	–	–	393	206	117	323
2008	–	–	367	187	117	304
2009	–	–	357	179	107	286
2010	–	–	364	194	99	293
2011	–	–	379	189	110	299
2012	–	–	343	144	129	273
2013	–	–	401	208	102	309
2014	–	–	352	177	110	287
2015	–	–	332	188	63	251
2016	–	–	308	157	76	233
2017	–	–	362	210	79	289
2005-2016 average:			*359.3*	*186.8*	*97.6*	*284.4*

Table 2. Monthly and annual number of survey days in Glacier Bay and Icy Strait, 1985-2017. The dashed line highlights a change in the way we calculated survey effort beginning in 2005 (see Neilson and Gabriele 2007).

	May		June[a]		July[a]		August[a]		September		Jun 1 – Aug 31	
Year	**GB**	**IS**	**GB**	**IS**	**GB**	**IS**	**GB**	**IS**	**GB**	**IS**	**GB**	**IS**
1985	0	0	10	7	11	4	10	3	0	1	**31**	**14**
1986	0	0	13	5	17	3	6	6	0	2	**36**	**14**
1987	3	2	12	5	12	7	5	7	1	2	**29**	**19**
1988	0	0	11	5	12	7	12	5	7	3	**35**	**17**
1989	3	1	17	6	14	6	16	7	1	4	**47**	**19**
1990	6	4	16	5	18	6	14	8	0	0	**48**	**19**
1991	7	3	14	7	17	6	13	4	6	3	**44**	**17**
1992	3	2	19	4	17	5	12	4	7	1	**48**	**13**
1993	2	1	10	3	13	3	7	5	1	1	**30**	**11**
1994	1	0	9	5	10	4	13	8	1	1	**32**	**17**
1995	3	2	10	4	11	4	10	7	2	2	**31**	**15**
1996	4	2	11	5	17	10	16	3	3	1	**44**	**18**
1997	5	2	17	4	21	7	19	6	9	4	**57**	**17**
1998	10	4	20	3	23	6	12	4	5	2	**55**	**13**
1999	4	1	16	4	18	6	18	3	5	1	**52**	**13**
2000	1	0	21	8	21	5	23	6	5	1	**65**	**19**
2001	3	1	17	6	14	5	20	5	6	2	**51**	**16**
2002	3	1	19	6	19	4	18	2	4	2	**56**	**12**
2003	5	0	20	7	19	5	16	5	3	1	**55**	**17**
2004	6	2	21	3	19	5	21	5	8	2	**61**	**13**
2005	1	0	16	5	17	3	12	3	4	3	**45**	**11**
2006	2	2	14	6	15	7	16	7	5	1	**45**	**20**
2007	4	2	15	10	14	7	14	6	5	2	**43**	**23**
2008	4	1	16	10	14	8	12	9	3	1	**42**	**27**
2009	6	5	12	10	16	9	10	5	5	4	**38**	**24**
2010	5	3	14	9	11	11	17	8	3	5	**42**	**28**
2011	3	1	13	10	14	6	13	7	5	3	**40**	**23**
2012	5	2	11	8	12	9	12	10	4	2	**35**	**27**
2013	7	4	13	7	16	12	19	7	5	1	**48**	**26**
2014	5	6	11	9	14	8	15	4	4	1	**40**	**21**
2015	5	2	16	4	15	6	14	5	5	1	**45**	**15**
2016	5	2	11	5	13	6	11	5	5	3	**35**	**16**
2017	7	2	15	5	17	5	10	9	5	4	**42**	**19**
2005-2016 average:			*13.5*	*7.8*	*14.3*	*7.7*	*13.8*	*6.3*	–	–	***41.5***	***21.8***

[a] The dedicated annual monitoring period (June 1 - August 31; also shaded).

Table 3. Annual whale counts not corrected for effort (June 1 - August 31), 1985-2017.

Year	Glacier Bay	Icy Strait	Glacier Bay & Icy Strait
1985	15	30	41
1986	32	29	46
1987	30	48	60
1988	41	36	54
1989	26	28	41
1990	25	33	49
1991	19	42	53
1992	34	51	66
1993	30	30	50
1994	29	42	60
1995	28	44	57
1996	44	60	78
1997	55	50	82
1998	63	50	92
1999	63	65	106
2000	59	58	90
2001	45	85	100
2002	44	61	85
2003	83	77	117
2004	112	74	144
2005	102	90	146
2006	84	123	152
2007	91	129	161
2008	86	139	160
2009	108	162	182
2010	131	145	193
2011	152	157	222
2012	125	177	209
2013	161	205	240
2014	99	125	175
2015	125	76	166
2016	117	100	165
2017	85	67	128

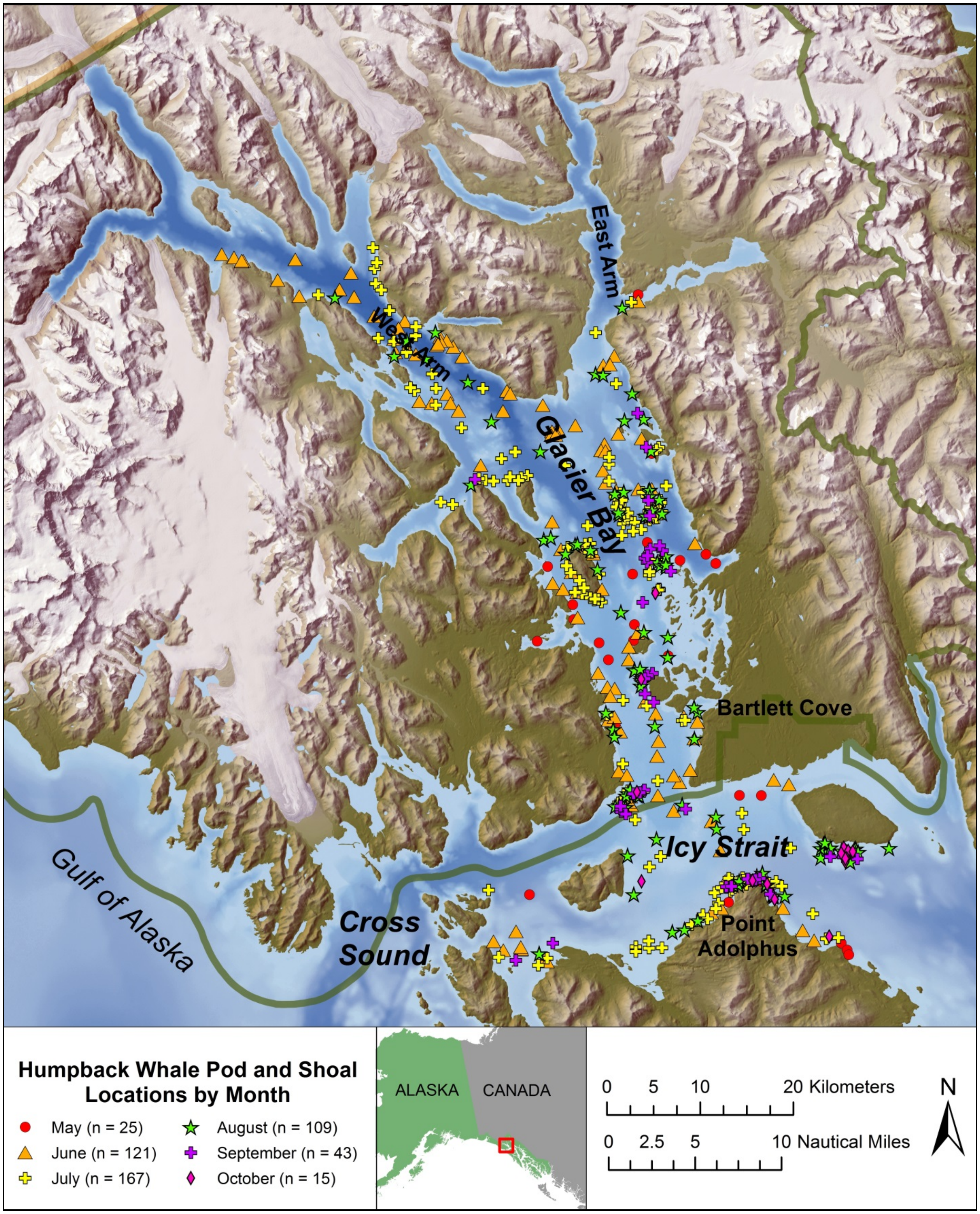

Figure 2. Study area in Glacier Bay and Icy Strait showing distribution of humpback whale pods and shoals in 2017. Each symbol represents a pod or shoal containing one or more whales.

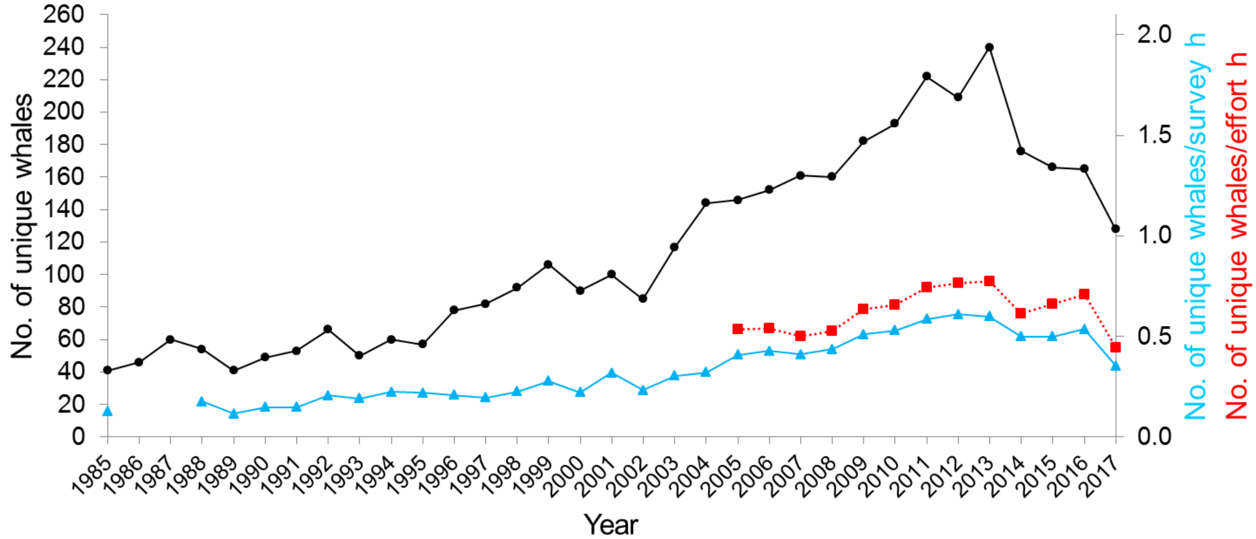

Figure 3. Relative abundance metrics for Glacier Bay and Icy Strait combined. Annual whale counts (black), whales/survey h (blue), and whales/effort h (red) in Glacier Bay and Icy Strait from June 1 - August 31, 1985-2017. Whales/survey h is not available for 1986-1987. Whales/effort h is not available for 1985-2004 because in these years we only recorded survey hours (see Neilson and Gabriele 2007).

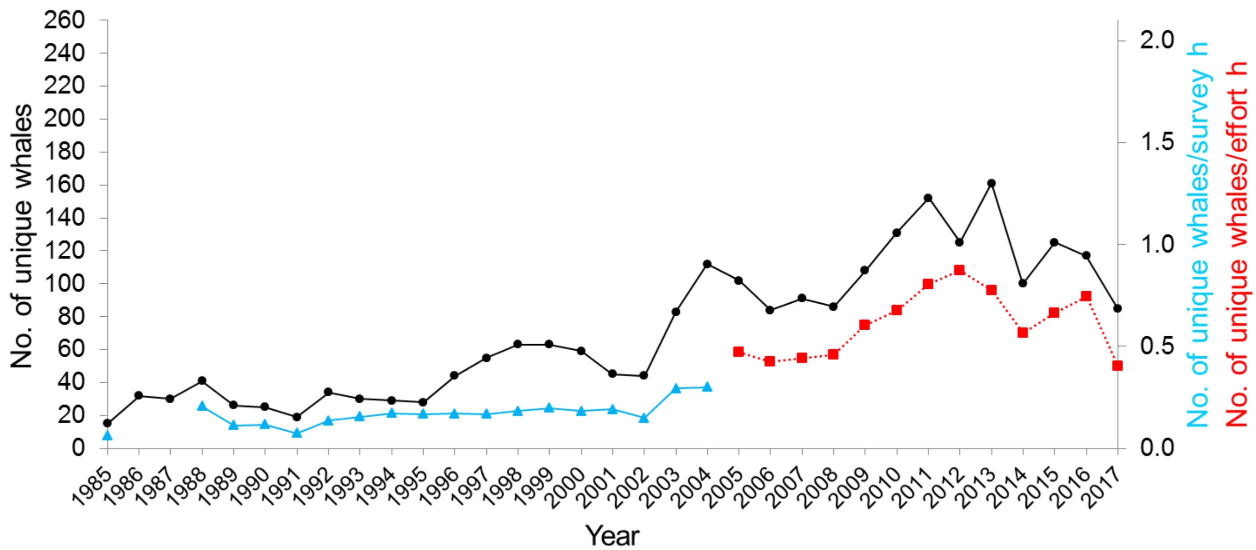

Figure 4. Relative abundance metrics for Glacier Bay alone. Annual whale counts (black), whales/survey h (blue), and whales/effort h (red) in Glacier Bay from June 1 - August 31, 1985-2017. Whales/survey h is not available for 1986-1987. Whales/effort h is not available for 1985-2004 because in these years we only recorded survey hours (see Neilson and Gabriele 2007).

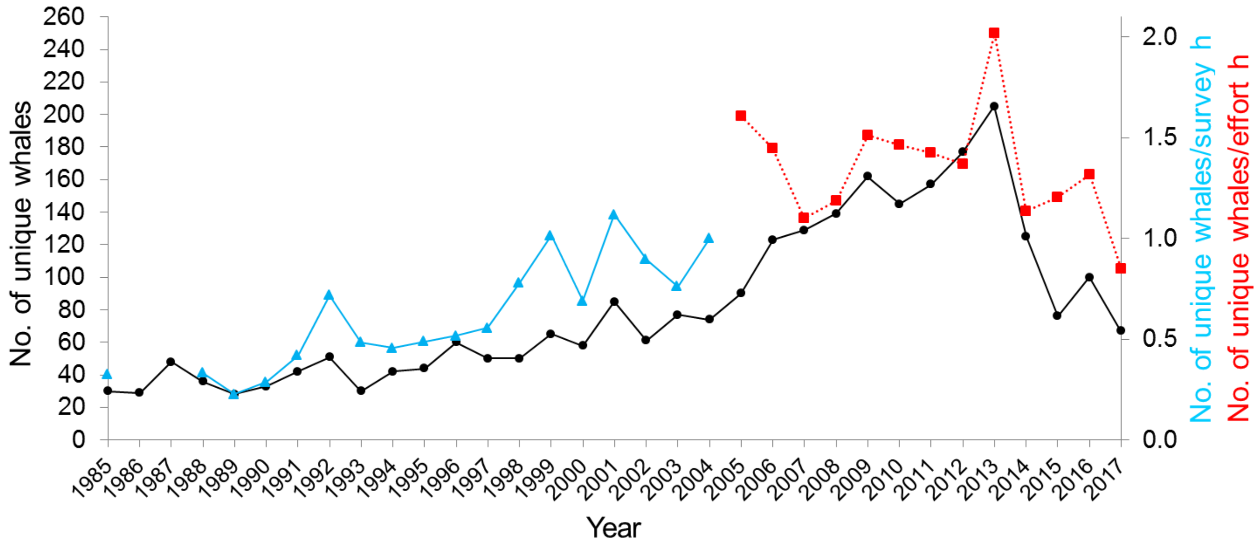

Figure 5. Relative abundance metrics for Icy Strait alone. Annual whale counts (black), whales/survey h (blue), and whales/effort h (red) in Icy Strait from June 1 - August 31, 1985-2017. Whales/survey h is not available for 1986-1987. Whales/effort h is not available for 1985-2004 because in these years we only recorded survey hours (see Neilson and Gabriele 2007).

By all measures of abundance, humpback whale numbers in the study area have declined by more than 40% since peaking in 2013. The long-term, consistent humpback whale monitoring in GB-IS is unique within Alaska, making it difficult to determine over what geographic scale the recent declines we have observed may have occurred. However, there is evidence that humpback whale abundance and distribution may have been atypical on a regional scale in recent years (Moran *et al.* 2018). Preliminary results from SPLISH (2016-2017) indicate relatively low numbers of humpback whales, including calves, elsewhere in the inside waters of northern SEAK (AWF, NOAA, NPS, and UAS unpublished data) and the crude birth rate in Sitka Sound appears to be declining (Straley and Moran 2017). Long-term cetacean surveys in SEAK (*e.g.*, Dahlheim *et al.* 2009) reported relatively low numbers of cetaceans in the inland waters of SEAK in 2015 and 2016 compared with previous years [including humpback whales, killer whales (*Orcinus orca*), and Dall's porpoise (*Phocoenoides dalli*)] (M. Dahlheim, pers. comm.), however no survey took place in 2017 for comparison.

Although little is known about humpback whale abundance and distribution in SEAK during the winter months, there is evidence of anomalies during the winter of 2016-2017. In November and December 2016, a time of year when humpback whales have historically gathered in very high numbers in Seymour Canal to feed on krill (*e.g.*, >130 individuals in 2015), deer hunters in the area reported seeing few to no whales or krill (Straley and Moran 2017). In early February 2017 (the peak of the breeding season when we would expect most humpback whales to be in Hawaii or Mexico), unusually high numbers of whales (40-60) were present in Sitka Sound. Notably, many appeared to be in poor body condition [abnormally thin, infested with external parasites (*Cyamus* sp.), etc.] (Straley and Moran 2017). It is unknown whether these humpback whales over-wintered in Alaska. Alternatively, they may have migrated but returned early from the breeding grounds or delayed their migration south. In the North Atlantic, humpback whales were found to shift their migratory timing to and from a feeding ground in an apparent response to rising sea surface temperatures, however these changes took place gradually over three decades (Ramp *et al.* 2015). To date, we have not attempted an analogous study to quantify potential shifts in the phenology of humpback whales in SEAK.

It appears that the declines and anomalies detected in SEAK may also be occurring more broadly in other parts of the central and eastern North Pacific in recent years. Cetacean surveys conducted in offshore areas of the central and western Gulf of Alaska in 2015 documented significantly fewer humpback whales in 2015 compared with 2013 (Rone *et al.* 2017). In addition, during the winter of 2015-2016, researchers in Hawaii and Mexico reported anomalously low numbers of humpback whales (including calves) on the breeding grounds, with many whales arriving late and leaving early (Hurley 2016; Loomis 2016; Frankel *et al.* in prep). During the winters of 2015-2016 and 2016-2017, the number of whales (including calves) sighted from a shore-based station in Hawaii was lower than in recent years (Frankel *et al.* in prep). An unusual spike in humpback whale strandings (n = 6) occurred in Hawaii from November 2016 - early January 2017, however the cause of death in these animals is unknown and strandings did not continue at unusual levels for the rest of the breeding season (NOAA unpublished data). Humpback whale surveys in 2017 in Prince William Sound, approximately 640 km (~400 mi) northwest of the study area, revealed unusually low whale numbers compared with past years and no calf sightings (NOAA and UAS unpublished data).

We suspect that the lower number of whales in recent years reflects regional declines in prey availability and/or prey quality in the greater Gulf of Alaska ecosystem. The hypothesis that whales are currently food-limited is supported by increasing observations of whales that appear to be malnourished (see below, Physical Condition). While it is possible that humpback whales are exceeding regional carrying capacity after decades of population growth, concurrent mass die-offs of other marine predators due to starvation (*e.g.,* seabirds) in the Gulf of Alaska in recent years indicate widespread regional prey shortages and disruption of the marine food web (Bond *et al.* 2015; Joling 2017; Walsh *et al.* 2018). An increase in disease/illness in SEAK humpback whales, perhaps related to harmful algal blooms (HABs) or other vectors, may also be contributing to declining body condition and abundance (*e.g.,* HABs were suspected in a mass die-off of large whales in the western Gulf of Alaska in 2015-2016; Lefebvre *et al.* 2016; Savage 2017), however there has been no marked increase in the number of dead humpback whales in SEAK in recent years [2010-2013 mean = 3.5 (range 0-7) *vs.* 2014-2017 mean = 3.8 (range 2-6); NOAA Alaska Region unpublished data]. Initiating systematic monitoring of the health status of live humpback whales in SEAK would help in interpreting current and future trends in abundance and body condition.

Environmental Conditions

Anomalously warm water temperatures persisted in the northeastern Pacific Ocean from fall 2013 through fall 2016 that we suspect may have negatively impacted humpback whale prey availability and/or quality. These conditions resulted from a combination of the warm water “Blob” that dominated in the northeastern Pacific Ocean from late 2013-2016, the 2014 shift to the warm phase of the Pacific Decadal Oscillation, a very strong El Niño in 2015-2016, and ongoing climate change. The effects of the resulting marine heat wave on humpback whales and their prey are generally unknown (however see Anderson and Piatt 1999), but unusually warm waters were implicated in a wide variety of cascading effects on the marine ecosystem (Bond *et al*. 2015; Di Lorenzo and Mantua 2016; Miller 2016; Rosen 2017; Walsh *et al.* 2018) and there is increasing evidence that consecutive years of warm water in the Gulf of Alaska have had an overall negative effect on ecosystem productivity. Warm water increases the metabolic demands of ectothermic fish, while at the same time it may exceed the thermal tolerance of some marine species and in some cases favor smaller and less-lipid rich zooplankton. The result is that under unusually warm conditions, many marine predators (fish, seabirds, and marine mammals) become prey-limited (Zador and Yasumiishi 2017).

Anomalously warm waters were detected by the SECM project in Icy Strait during summers 2015 and 2016, with 2016 representing the highest deviation above average in the ISTI (~1.2˚C warmer) in 20 years of monitoring (Fergusson *et al.* 2017b). In 2016, these above-average water temperatures coincided with relatively high densities in some zooplankton taxa (*e.g.*, hyperiid amphipods and gastropods) but below average and declining densities in other taxa (*e.g.*, euphausiids and small calanoid copepods) that are important as forage fish prey (and, in the case of euphausiids, humpback whale prey) (Fergusson *et al.* 2017b). In addition, above-average water temperatures were associated with a three-fold decline in zooplankton lipid content between 2014 and 2015 (Fergusson *et al.* 2017a), demonstrating how important it is to track trends in zooplankton quality (% lipid) along with quantity.

It is notable that in 2017, the SECM project documented cooler than average water temperatures in Icy Strait (2017 ISTI = 8.93˚C *vs*. 1997-2016 mean = 9.4˚C, range 8.3˚C-10.6˚C; Fergusson *et al.* 2017b; Fergusson *et al.* 2018; Fergusson pers. comm.), yet whale numbers in this area were low (Figure 5). It seems plausible that if colder water temperatures are favorable to some humpback whale prey (*e.g.*, some species of forage fish and euphausiids), there may be a lag time between the return of colder conditions and local increases in whale prey abundance and/or quality, although we recognize that this may be an over-simplification of a complex system. In the Gulf of Maine, changes in the distribution and abundance of calanoid copepods appear to be driven by climate-associated ecosystem regime shifts that affect oceanographic conditions (*e.g.*, water temperature and seasonal stratification of the water column) following lags of 2-4 years (Meyer-Gutbrod *et al.* 2015). Therefore, we suspect that above-average water temperatures in 2013-2016 may be playing a critical role in reducing prey availability and/or quality, but that there may be a lag in the response of the system to cooler temperatures.

As we have described in previous reports, we also suspect that part of the sudden decline in whale abundance in GB-IS in 2014 is attributable to a July 25 earthquake that generated one or more submarine landslides that greatly increased turbidity locally, likely leading to decreased whale foraging success in lower Glacier Bay and Icy Strait (Neilson *et al.* 2015). The short- and long-term effects of these landslides on forage fish habitat, abundance, distribution, and survival are unknown but we speculate there may have been long-term effects on local forage fish populations.

Physical Condition

Each year we typically observe a few “skinny” whales, especially in the spring when whales return from fasting during their annual migration to the breeding grounds. However, for the second year in a row, we observed many abnormally thin whales (2016 = 13%; 2017 = 24%) (*e.g.*, cover photo) with the higher rate in 2017 suggesting increased malnutrition in the population over time. Similar to 2016, we continued to document new thin individuals throughout the summer, even as late as September 12. Decreased body condition is most likely attributable to lack of food but may also indicate illness or disease. During an Unusual Mortality Event in 2015-2016, emaciated fin whales (*Balaenoptera physalus*) found dead in British Columbia were suspected of succumbing to malnutrition due to decreased prey availability or decreased ability to forage because of toxin exposure from HABs (Savage 2017). Elsewhere in northern SEAK, preliminary results from SPLISH indicate there may have been fewer skinny whales in 2017 than in 2016, however formal photographic analyses have not been completed.

We documented unusual skin conditions in adult male whales #118 (age unknown), #352 (age 33), #1293 (age 23), #1485 (age 17), and #1838 (age 13). These whales' skin appeared gray/blotchy (*e.g.*, Figure 6), roughened/granular (*e.g.*, Figure 7), and/or pocked (*e.g.*, Figure 8). A humpback whale documented in Sitka Sound in February 2017 had a similar roughened/granular skin condition that researchers speculated may have been due to cyamids eating the skin (Straley and Moran 2017). On July 19, local whale-watch captain Tod Sebens (M/V *Taz*) photographed whale #118 pectoral fin slapping and documented diffuse bleeding emanating from what appear to be numerous small holes on the ventral side of #118's pectoral fin (Figure 9; T. Sebens, pers. comm.). While we do not know the cause of these unusual skin conditions, we suspect that they may be related to a current or recent cyamid infestation. Of these four whales, three (whales #118, #352, and #1293) also appeared to be skinny in 2017.

Our opportunistic observations of the physical condition of whales in GB-IS are subjective, influenced by lighting/sea state/etc., and constrained by our limited vantage point alongside the animals as they surface (*i.e.*, we can only see a portion of their bodies). Standardized health assessment protocols are needed to quantify the rate and severity of malnutrition and other health problems in the population. In addition, directed, systematic health assessments using emerging technologies may be beneficial (*e.g.*, unmanned aerial vehicle photography and/or microbiome sample collection; *e.g.*, Christiansen *et al.* 2016; Apprill *et al.* 2017; Fiori *et al.* 2017).

Figure 6. Adult male #352 with gray/blotchy skin condition on June 20, 2017.

Figure 7. Adult male #118 with roughened/granular skin condition on June 29, 2017.

Figure 8. Adult male #1485 with pocked skin condition on June 29, 2017.

Figure 9. Adult male #118 with bloody pectoral fin on July 19, 2017. Photo courtesy of Tod Sebens.

Site Fidelity

Within-year residence times and year-to-year return to the study area are metrics of habitat use. The historically high rate of within-season residency in the study area highlights the importance of the Glacier Bay-Icy Strait region as a summer feeding ground for many humpback whales. At a finer scale, monitoring results over many years have shown that while some whales are exclusive residents to either Glacier Bay or Icy Strait, many whales move frequently between the two areas. In 2017, 65 of the 128 whales (51%) that we documented in the study area between June 1 and August 31 were resighted 20 or more days apart, meeting our definition of resident. This proportion is lower than average historic values (1985-2016 mean = 62%, SD = 8%) and compared with the past 20 years, only 2014 had a lower proportion of residents (48%).

Another indication of lower site fidelity in 2017 was a higher than average proportion of transitory whales (n = 40, or 31%; 17 in GB and 23 in IS). The proportion of transitory whales varies widely each year (1985-2016 range = 17%-42%, mean = 26%, SD = 6%) but the proportion in 2017 was above average. We observed two pulses of transitory whales: five transitory whales were present in western Icy Strait on June 20 and four were present in central Icy Strait on August 9, otherwise we saw the reported transitory whales distributed broadly through the study area and summer.

Many whales in the study area return year after year (Gabriele *et al.* 2017) indicating some level of dependence on the resources and health of the GB-IS ecosystem. We examined between-year site fidelity using our newly created criteria for ‘regularly sighted’ whales. Sixty-six whales (24 females, 36 males, 6 unknown sex) met these criteria (*i.e.*, documented in GB-IS for 10 consecutive summers 2004-2013) (Appendix A). In 2014-2017, nearly half (n = 29, 44%) of these ‘regulars’ (16 females, 11 males, two unknown sex) appeared to interrupt their annual return to the study area because we did not see them for at least one summer, breaking their long-term pattern of observed site fidelity to GB-IS. We also found that the number of regulars that were absent increased annually (2014, n = 5; 2015, n = 9; 2016, n = 14; 2017, n = 26) such that by 2017, we did not see 39% (26 of 66) of the whales regularly sighted in 2004-2013.

In a comparison between sexes, we found that males were significantly more likely than females to be regularly sighted in GB-IS. Considering all whales of known sex that were available to be observed 2004-2013 (67 males, 78 females), the proportion of males that we regularly sighted (55%, n = 36) (*i.e.*, documented in all 10 years) was significantly higher than the proportion of females that we regularly sighted (36%, n = 24) (two-tailed Fisher’s exact probability test, p = 0.007). It is unclear why males would exhibit higher between-year site fidelity to GB-IS than females, although we hypothesize that habitat use is related to a female’s variable nutritional needs depending on reproductive status. Sex-biased habitat stratification has been documented for humpback whales on feeding grounds in the Gulf of Maine (Robbins 2007).

In addition, we found that males were more likely than females to maintain this site fidelity to GB-IS in recent years. Considering only regularly sighted whales of known sex (24 females, 36 males), the proportion of females that appeared to interrupt their regular return in 2014-2017 (55%, n = 16) was significantly higher than the proportion of males that appeared to interrupt their regular return in 2014-2017 (38%, n = 11) (two-tailed Fisher’s exact probability test, p = 0.008). Because the fate of so many of the absent regulars is unknown, it is unclear why females' site fidelity in recent years appears to be impacted more than males. Adult female humpback whales are larger than males and have a much higher energetic demand in reproduction, which may make them more vulnerable to starvation in years with reduced prey availability and/or quality. Alternatively, females may be more flexible than males in seeking new feeding locations outside GB-IS during years when prey abundance and/or quality decline.

The fate of six of the 26 absent regulars is known based on sightings of these whales outside of our June 1-August 31 monitoring period in GB-IS. Two regulars (male #157, female #250) were present in Icy Strait in May (NPS unpublished data) and three more (males #937 and #1817, female #1421) were documented in Chatham Strait in late July during SPLISH surveys (NOAA unpublished data). These sightings indicate temporal and geographic shifts in these whales' long-term fidelity to the study area during the core summer months. An additional regular that we did not see in 2017 (male #616) was documented in Icy Strait on August 2 (NOAA unpublished data) and west of the study area on September 5 (M. Greenfelder/www.Happywhale.com unpublished data).

The fate of the remaining absent regulars in 2017 (n = 20) is unknown but could be resolved by future sightings. Nine of these 20 individuals are of known age (ranging from 19-43 years old), well below the maximum known life expectancy for the species (96 years old) (Chittleborough 1959). Historically, the annual survival rate among non-calf humpback whales in SEAK has been very high (1994-2008 = 0.996, 95% central probability interval: 0.984, 0.999) (Hendrix *et al.* 2012), however adult survival likely changes in response to ecological factors. As noted previously, available records indicate that the number of dead humpback whales found in SEAK in recent years has not been unusually high (NOAA Alaska Region unpublished data), however whales that die during the open ocean migration to Hawaii [~4000 km (~2500 mi) each way] are unlikely to be found due to the remoteness of the area. At least three of the regularly sighted whales that we did not see in 2017 (females #232, #1014, and #1233) appeared to be abnormally thin in 2016, but we do not know if their compromised body condition led to mortality. In the vulnerable and well-studied population of North Atlantic right whales (*Eubalaena glacialis*), severely emaciated whales have a decreased survival rate (Pettis *et al.* 2004) of approximately 15% (R. Rolland, pers. comm.). We suspect that female #1014 (born in 1989) has died based on her extremely emaciated condition and infestation with external parasites (*Cyamus* sp.) in 2016 (Neilson *et al.* 2017).

There is evidence that some whales may have shifted their summer distribution in recent years, which could account for some of the declines in abundance and site fidelity that we have documented. We documented four regularly sighted whales that appeared abnormally thin in 2016 in 2017 (female #250 and males #157, #937, and #616), although #250 also appeared malnourished in 2017. However, all four of these whales appeared to shift away from GB-IS as their core feeding area in 2017 because their sightings occurred outside of our June 1-August 31 monitoring period in GB-IS. While SPLISH has allowed an August snapshot of whale distribution in northern SEAK, the Gulf of Alaska and southern SEAK are potential areas where whales may be relocating. In May we received a third-hand report of about100 humpback whales feeding offshore of southwestern Baranof Island (J. Moran, pers. comm.) and in early June we received a report of 60 or more humpbacks feeding offshore of northwestern Chichagof Island (F. Braden, pers. comm.). Increased photographic identification effort in areas of SEAK with poor survey coverage would help determine if more whales are shifting their distribution to new feeding locations. In addition, increased comparison of SEAK and British Columbia fluke catalogs would be valuable in assessing possible shifts in distribution on a broader geographic scale (Neilson *et al.* 2018).

Reproduction and Juvenile Survival

We identified only two mother/calf pairs in 2017, which led to the second lowest crude birth rate (CBR) (1.6%) since monitoring began in 1985 (Figure 10). Both mothers (11-year-old female #2024 and 13-year-old female #1846) appeared to be abnormally thin (Figure 11) and we encountered both pairs only once with their calves in June. Whale #1846 and her calf were also documented on May 10 in Chatham Strait (M. Kosma/UAS unpublished data). On July 19, we observed #1846 for more than an hour, at which time her calf was absent. We did not see #1846 on any subsequent surveys to confirm her calf's absence.

2017 marks the fourth consecutive year of calving anomalies in the study area, with a decreasing trend in CBR and an increasing trend in absent calves. For comparison, from 1985-2013, we observed a mean of 9.3 calves/yr (range 2-21, SD = 4.8) and a mean CBR of 9.3% (range 3.3%-18.2%, SD = 3.9%) (Figure 10). During this same period, suspected calf losses during the summer feeding season were extremely rare (8 out of 270 calves) with no more than one missing calf per year. Beginning in 2014, calf numbers were initially high (n = 14), however by fall an unprecedented number of mothers (n = 5) appeared to have lost their calves (Neilson *et al.* 2015) and none of the remaining calves (n = 9) have been resighted in subsequent years. In 2015, the CBR represented a historic low (3.0%) with relatively few calves (n = 5) (Neilson and Gabriele 2016), none of which

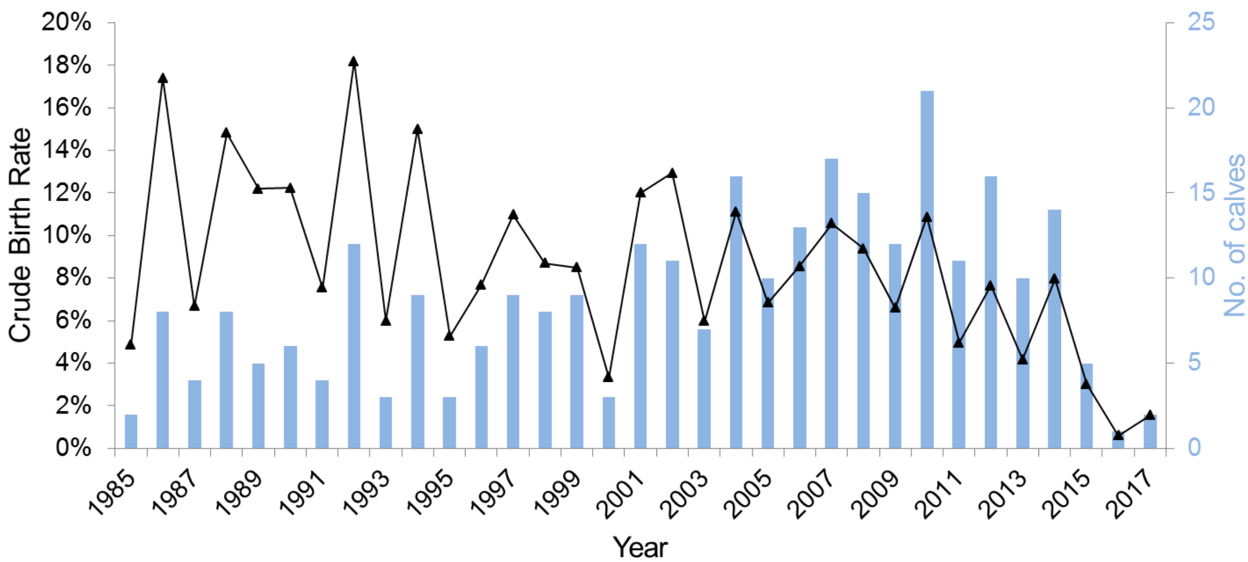

Figure 10. Crude birth rate (black line) and annual number of calves (blue bars) in Glacier Bay from 1985-2017.

Figure 11. Abnormally thin 13-year-old female #1846 observed July 19, 2017 without her calf. Note visible scapula (shoulder blade) and depression behind blowholes.

have been resighted. In 2016, we documented one mother/calf pair (both appeared to be abnormally thin), which led to the lowest crude birth rate (0.6%) since monitoring began (Neilson *et al.* 2017). In 2017, the CBR was the second lowest on record (1.6%) and one of the two mothers that we documented appeared to have lost her calf by mid-July. While we would expect fewer calves in years with lower whale abundance (*e.g.*, 2014 and 2017), the sharp decline in CBRs and the unusually high number of missing calves in recent years are unexpected. We received very few reports of calves from other observers, indicating that mother/calf pairs were uncommon in Glacier Bay and Icy Strait in 2017 (J. Helm, B. Cannamore, S. Van Derhoff, and K. Thompson, pers. comm.).

Preliminary results from SPLISH reveal that between 22 July and 5 August 2017, calf numbers were anomalously low in other areas of northern SEAK, with only three mother-calf pairs observed (AWF, NOAA, and UAS unpublished data). We are aware of only one other mother-calf pair anywhere in northern SEAK in 2017 (observed May 12 in Frederick Sound, however no photographs were obtained so this may be the same as one of the subsequently observed pairs; M. Kosma/UAS unpublished data). These pairs (3 SPLISH, 1 non-SPLISH), plus the two pairs we documented in GB-IS, represent a maximum of six mother-calf pairs in northern SEAK in 2017. We do not know if the calving rate has declined in the entire Hawaii DPS or just in SEAK. As noted previously, during the winters of 2015-2016 and 2016-2017, the number of calves sighted from a shore-based station in Hawaii was lower than in many previous years, indicating that the entire DPS may be affected (Frankel *et al.* in prep).

We did not document any known juveniles (whales age 1-4 years, as determined by prior sighting history) in 2017. Out of 30 calves that we documented in the study area from 2013-2016, only two individuals (7%) are known to have survived to be juveniles in the GB-IS population (both were calves from 2013) but we saw neither in 2017. While the mean age at which calves return to the study area is 3.2 years (Gabriele *et al.* 2017) and juvenile whales can be difficult to track and photo-identify based on their small size and tendency toward erratic behavior, 2017 was the first year since 1989 that we documented no known juveniles in the study area. Given the low calving rates we documented in 2015 and 2016, it is not surprising that we saw few very young (1-2 year old) whales in 2017, however the overall lack of all juveniles was unexpected and suggests a decline in juvenile survival and/or site fidelity in recent years. We do not systematically document body size, and assessing the length of whales at sea is difficult, however we do opportunistically note when an animal appears to be "small." In 2017, we noted only eight small whales during our surveys (five were later identified as known whales ages 5- 9). We suspect that these changes in calving and juvenile return rates are related to changes in prey availability and/or quality which are affecting body condition and in turn negatively affecting female reproductive success and/or juvenile survival (Bradford *et al.* 2012; Pettis *et al.* 2004; Seyboth *et al.* 2016). In addition, local reductions in prey availability and/or quality could be causing declines in juvenile fidelity to the study area. Recruitment from local populations (*vs.* immigration from outside populations) is a key driver of population growth over the past 30 years in the study area (Pierszalowski *et al.* 2016), therefore sustained declines in calving and/or recruitment will have long-term effects on the GB-IS whale population and could impact tourism in this area.

There are many parallels between the declines we have documented in calf production and adult body condition and a UME involving Eastern North Pacific gray whales (*Eschrichtius robustus*) in 1999-2000. During this event, hundreds of gray whales (primarily adults), many of them emaciated, stranded along their migratory route on the west coast of North America (Le Boeuf *et al.* 2000; Brownell and Weller 2001; Moore *et al.* 2001; Gulland *et al.* 2005). In addition, calf counts in 1999-2001 were extremely low (Brownell and Weller 2001) and researchers documented aberrations in migratory timing and feeding timing/locations (Le Boeuf *et al.* 2000). While gray whales may have been reaching or exceeding carrying capacity after decades of population growth, oceanographic factors (*e.g.,* a strong El Niño in 1997-1998) that reduced prey availability were suspected as the primary cause of the UME (Brownell and Weller 2001; Carretta *et al.* 2017). The UME was a short-term, acute event and the gray whale population has since recovered to pre-UME levels (Carretta *et al.* 2017), offering hope that humpback whales may rebound from the recent declines we have documented here.

Tissue Samples

In 2017 we collected six sloughed skin samples from five unique whales, including one calf. This is fewer samples than in recent years (2007-2016 mean = 17.1, range = 9-29), in part reflecting the relatively low number of whales present in the study area. However, in 2017 we also observed very few "surface active" whales (*e.g.,* breaching, tail slapping, etc.), and it is these behaviors that often lead to shedding sloughed skin into the water. Between June 1 and August 31, only six pods out of 366 (1.6%) were surface active. This is a lower proportion than in recent years (2007-2016 mean = 5.6%, SD = 1.6%) but it is unclear why whales appeared to be less surface active in 2017.

Since 1996, we have collected 332 sloughed skin samples in the study area. Genetic analysis of these samples allows sex determination, definition of mitochondrial DNA haplotype, and nuclear DNA genotyping and these results have contributed to several humpback whale genetic studies (*e.g.,* Baker *et al.* 2013, Pierszalowski *et al.* 2016).

Feeding Behavior and Prey Identification

We do not routinely record exactly how long whales dive while they are feeding, but dives average ~5 minutes in the study area (NPS unpublished data). This year was unusual because we observed several whales make extremely long dives. The longest dive occurred on May 19 when we documented adult female whale #250 make a 26-minute dive while feeding in 37 m of water off the Gustavus forelands. The sighting conditions were excellent and we are confident that we did not miss a surfacing. At the time, we observed a dense layer of prey on the *Sand Lance*'s sonar extending from ~30 m depth to the ocean floor that we presume she was targeting. During the same encounter, we also documented #250 make a 17 minute dive. Throughout the summer, we observed and received at least seven additional reports of whales making unusually long (10-20 min) dives in a variety of locations in GB-IS (NPS unpublished data; J. Helm, pers. comm.).

There is no systematic monitoring of forage fish in the study area to confirm that species consumed by humpback whales have declined locally. However, the Alaska Department of Fish and Game monitoring of herring biomass at nine spawning areas in SEAK (the closest to the study area being Tenakee Inlet, approximately 75 km from the study area) shows a period of high regional productivity from about 2005-2011, followed by substantial declines in recent years (Hebert and Dressel 2017). Our and others' anecdotal observations of a decrease in herring in Icy Strait beginning in 2014, especially around Point Adolphus (Neilson *et al.* 2015; Neilson and Gabriele 2016), are consistent with declines in whales/effort h in Icy Strait in 2014-2017 compared with higher levels in 2009-2013 (Figure 5).

Examining the diets of larger pelagic fish (*e.g.,* salmon) which prey on forage fish in the study area may offer some insights into recent forage fish trends. Overall, SECM surveys in Icy Strait in 2017 found a high proportion (60%) of fish stomachs were empty compared with previous years (2013-2016 range 12%-35%). In addition, they documented a dramatic decline in capelin from 31.7% of fish stomach contents in 2013 (n = 315 stomachs analyzed) to 0% in 2016 (n = 45 stomachs analyzed) and 2017 (n = 62 stomachs analyzed). Declines in capelin are relevant because capelin are important, high-lipid prey for humpback whales in the study area (Anthony *et al.*2000; Gabriele *et al.* 2017; NPS unpublished data). From 2013-2016, herring comprised a variable but low proportion of fish diets (0.2%-5.3%) but in 2017 they increased to 12.3%. This apparent increase in the relative availability of herring is consistent with our and others' observations of herring around Pleasant Island in August 2017. From 2013-2015, the proportion of walleye pollock varied (0.4%-9.1%) but in 2016, pollock increased to 23.7% of fish diets. In 2017, no pollock were detected (NOAA unpublished data). These apparent inter-annual changes in forage fish availability in Icy Strait likely affect the myriad of predators that rely on them, including humpback whales.

In 2016 and 2017, we detected capelin less often near feeding whales than in past years. The only confirmed detection in 2017 was a sample that we collected on August 15 with a dip-net near a whale feeding off the northwest shore of Young Island. On August 7 we observed a whale lunge feeding off the north shore of Willoughby Island on a school of fish that resembled capelin but we were unable to confirm the species. Capelin have a distinctive cucumber-like smell (Johnson *et al.* 2015) that in the past we have frequently detected near feeding whales (*e.g.,* 2015, n = 9), however in 2016 there were only two occasions when we noted the tell-tale cucumber smell in the air and in 2017 we never smelled capelin near feeding whales.

On July 13, while north of Willoughby Island, we photographed a gull near a feeding whale that caught a Pacific sandfish (*Trichodon trichodon*). This is not a forage fish species that we have documented previously near feeding whales in the study area. Interestingly, on July 19 we had another possible detection of Pacific sandfish near a whale that was feeding off Point Carolus, however we were unable to confirm the species.

On June 27, we opportunistically dip-netted young-of-the-year walleye pollock near a whale feeding outside Tidal Inlet. On July 25, we observed Pacific sand lance boiling at the sea surface near two different whales that were feeding off Flapjack Island. We attempted to collect a sample but they evaded the dip-net. In our experience, sand lance and walleye pollock are more difficult to detect visually than either herring or capelin which are relatively large, seem to have a greater tendency to boil at the sea surface in very tight schools, and (in the case of capelin) have a distinctive smell that aids in detection.

In early to mid-August, local recreational fishermen reported catching coho salmon (*Oncorhynchus kisutch*) near Pleasant Island with "stomachs full of adult herring" (C. Murdoch, pers. comm.). By August 24, humpback whale numbers in this area had increased and we documented a large group of whales (~10 individuals) bubblenet feeding around the Pleasant Island reef. On August 29, we documented several whales feeding around Pleasant Island, including a group of ~11 humpback whales that were bubblenet feeding. These whales were targeting herring and the August 29 group contained several individuals that are typical Point Adolphus 'core group' members (#155, #397, #1474) that had not been documented previously in GB-IS in 2017. On September 14, we observed single whales continuing to feed on herring around Pleasant Island.

Group bubblenetting in the study area is rarely reported. In 2011, we observed a group of eight whales bubblenet feeding in Pinta Cove near Point Adolphus (Neilson *et al.* 2011). Prior to that observation, the last report of group bubblenet feeding that we received occurred in 2003 (Doherty and Gabriele 2003). Although it is outside our study area in Icy Strait, we received reports of 5-10 humpback whales group bubblenet feeding in Port Frederick in early May and late October (Alaskan Dream Cruises, B. Flory/Alaska Marine Highway System, and M. Moss pers. comm.) and 3-7 (or more) humpback whales group bubblenet feeding in Excursion Inlet (L. Szybura, pers. comm.).

We did not detect any herring in Glacier Bay in 2017, although large schools were observed near the Bartlett Cove dock outside of "whale season" in late January 2017 (S. Schaller, pers. comm.). For the second year in a row, we detected no herring around Point Adolphus. Until 2014, it was not uncommon for us to document herring near whales feeding around Point Adolphus. From 1985-2012, Point Adolphus was a consistent hot spot for high numbers of humpback whales, including the 'core group' that appeared to target herring as their primary prey. However, 2017 was the fifth year in a row that we have documented low numbers of whales around Point Adolphus. Beginning in 2013, the core group did not appear to form for the first time since monitoring began in 1985, although we documented many of the whales commonly associated with the group scattered around the study area (Neilson *et al.* 2014). In 2014 and 2015, we documented a relatively small version of the core group, containing fewer than 10 individuals (Neilson *et al.* 2015; Neilson and Gabriele 2016). In 2016 and 2017, it appeared that the core group never formed and we never documented most of the whales typically associated with the group elsewhere in the study area (nor elsewhere in northern SEAK; AWF, NOAA, and UAS unpublished data).

While our whale prey observations are opportunistic and may be biased towards easier to detect species (*e.g.,* capelin, herring), in a long-term study of three puffin species, Sydeman *et al.* (2017) concluded that long-term studies of predator food habits are useful for elucidating changes in the spatial and temporal availability of prey species in marine ecosystems. A dedicated, long-term forage fish monitoring program in Glacier Bay and Icy Strait is needed to more fully understand and interpret observed changes in the abundance, distribution, and health of humpback whales and other marine predators over time in the study area.

Whale/Human Interactions

Whale Waters

For most of the summer, high numbers of whales were present in the lower West Arm, with many making long dives and frequenting mid-channel in an area of high vessel traffic. This prompted a variety of temporary whale waters designations in the West Arm from June 22-August 10. In addition, from mid-July until mid-August, whales concentrated around the Marble and Leland Islands, where temporary whale waters were implemented from July 12-August 10.

2017 was notable for being the first year since monitoring began that a reduced (13 kt) vessel speed limit was not implemented in lower Glacier Bay. By regulation (Title 36 CFR Subpart N, 13.1176), a 20 kt vessel speed limit is in place annually in lower Glacier Bay from May 15 - September 30 to help protect humpback whales from collisions and disturbance. For decades, high numbers of whales have concentrated to feed in the lower bay during the summer months, at which time a reduced speed limit (1985-2002 = 10 kt; 2003-present = 13 kt) is implemented to afford these whales additional protection. In 2001, the reduced speed limit was not applied in lower Glacier Bay until August 31 but remained in place until the end of September. In all other years, the reduced speed limit was implemented by August 10 at the latest. In 2016, the 13 kt speed limit was in effect for a shorter duration (55 days) than had been typical in recent years (2007-2015 range = 75-143 days, mean = 113 days). In 2017, whales did not concentrate to feed in lower Glacier Bay as they have done consistently for decades, although whales had to have at least passed through the area to reach mid and upper Glacier Bay where higher concentrations formed.

Vessel Collisions

Two whale-vessel collisions were reported in the study area in 2017. At approximately 3AM on July 8, a 14 m (47 ft) sailboat anchored in Blue Mouse Cove in the lower West Arm of Glacier Bay was struck by one or more humpback whales. The people onboard reported that vessel abruptly “rose and then fall hard.” Moments later they observed four whales (three large animals and one small animal that was not a calf) near the boat. One of the large whales made a wheezing sound for 3-4 breaths and then resumed normal breathing. They did not see any blood in the water and the whales stayed in the area after the collision. The vessel sustained major structural damage with a cracked engine shaft. We did not observe any injured whales in Glacier Bay following this incident and the fate of the whale(s) involved is unknown. Reports of whales striking anchored vessels are rare; from 1978-2011, only six cases were reported in Alaska out of 108 reported collisions (Neilson *et al.* 2012).

On July 20, a 12 m (40 ft) commercial whale watch vessel near Point Adolphus reported accidentally striking a humpback whale at approximately 13 kt while accelerating. The operator saw a whale blow directly off the bow and powered down, then felt a bump. He observed the whale surface behind the boat but it did not appear injured (NOAA Alaska Region unpublished data).

A series of photographs posted on social media showed what appears to be a near collision between a ~7 m (~22-24 ft) vessel and a breaching humpback whale at Point Adolphus, however no official report on this incident was submitted to NOAA.

In addition, in 2017 there were several near misses in which whales surfaced within 300 m of the bow of transiting cruise ships in the lower West Arm of Glacier Bay (NPS unpublished data). On August 23, 2017 we confirmed the survival of 10-year-old male whale #2029, an individual involved in a near miss with a cruise ship in Glacier Bay on August 12, 2016 (Neilson *et al.* 2017; NPS unpublished data). We had presumed that this whale successfully evaded the ship during the 2016 encounter, however his fate was uncertain until this year's sighting.

Elsewhere in SEAK, five whale-vessel collisions were reported. At twilight on May 12, a 293 m (960 ft) cruise ship reported striking a whale in southern Chatham Strait. The ship was transiting at approximately 20 kt when a whale suddenly surfaced approximately 15-20 m (50-65 ft) ahead of the bow. The bridge crew had not been aware of the whale's presence prior to the strike and they were unable to identify the species of whale. They felt the ship shudder and did not see the whale surface again (NOAA Alaska Region unpublished data). Based on the size and speed of the ship, this strike was likely lethal to the whale, however no carcass was reported subsequently in the area.

A "bubble feeding" humpback whale reportedly came up under a commercial whale watching boat in Hoonah harbor on June 9, possibly shaking the vessel. The whale left the area immediately and no further details are available (NOAA Alaska Region unpublished data).

On August 9, the 290 m (951 ft) cruise ship *Grand Princess* arrived in Ketchikan with a dead sub-adult male humpback whale pinned to its bulbous bow. A necropsy found that the animal was in average body condition and had died from trauma consistent with a ship strike (NOAA Alaska Region unpublished data).

On August 21, a self-guided charter fishing boat transiting at approximately 25 kts in Cross Sound was observed by another boater striking a humpback whale with its bow. The vessel continued on its way following the impact, while the reporting vessel stayed in the area in an attempt to assess the whale. About 15 minutes later, a whale surfaced in the area that did not appear injured, however there was another whale in the vicinity and the reporting vessel could not be sure they were examining the whale that had been struck (NOAA Alaska Region unpublished data).

On September 13, a witness reported seeing a 18 m (58 ft) commercial fishing vessel strike a humpback whale near Sitka but the captain stated that no strike occurred. The reporting vessel stayed in the area to assess the whale and did not see any blood in the water or unusual behavior following the incident (NOAA Alaska Region unpublished data).

Elsewhere in Alaska, one collision involving a humpback whale was reported. On June 18, the captain of a ~7-8 m (~24-28 ft) charter vessel reported striking a humpback whale in Emerald Cove near Seward. The vessel was transiting at approximately 22 kts at the time of the collision. Following the strike, the captain and crew observed the whale swimming away from the vessel. They did not see any obvious external injuries but they did observe a small amount of blood in the water (NOAA Alaska Region unpublished data).

Overall, the number of collision reports from vessel operators in Alaska in 2017 was higher than in 2016 (n = 0) but comparable to prior years (2014, n = 6; 2015, n = 5) (NOAA Alaska Region unpublished data).

Dead Whales

No dead humpback whales were reported in the study area in 2017. Elsewhere in SEAK, two dead humpback whales were reported (NOAA Alaska Region unpublished data). One of the animals was struck by a cruise ship (see above, Vessel Collisions) but the cause of death in the other whale observed floating in Clarence Strait on August 22 is unknown (NOAA Alaska Region unpublished data).

The Unusual Mortality Event (UME) that NOAA declared in August 2015 for large whales in the western Gulf of Alaska and British Columbia was closed in November 2017 (Savage 2017). The UME was initiated due to a large number of dead fin whales in 2015, with humpback whales later added to the investigation. The cause(s) of the UME remains undetermined but broad ecologic changes are suspected (Savage 2017). In 2017, 21 dead humpbacks were reported state-wide in Alaska (SEAK, n = 2; Gulf of Alaska, n = 6; south central Alaska, n = 8; Bering Sea, n = 5) (NOAA Alaska Region unpublished data). For comparison, in 2015, during the UME 31 dead humpback whales were reported in Alaska (Savage 2017).

Entangled Whales

No entangled humpback whales were reported in the study area in 2017. Reports of entangled whales in the study area are rare and generally do not exceed one per year (NPS unpublished data).

Elsewhere in SEAK, at least five entangled humpback whales were reported (NOAA Alaska Region unpublished data). Two of these entanglements were notable because they involved humpback whales getting wrapped in heavy gauge cables/anchor lines. Entanglements in anchor lines are uncommon (the majority of entanglements involve fishing gear and/or marine debris; NOAA unpublished data), although there was another recent case (June 2016) of an adult humpback whale becoming entangled in anchor line in Seymour Canal (Neilson *et al.* 2017; NOAA Alaska Region unpublished data).

The first report was received on January 3 when a humpback whale became entangled in a 25 mm (1 in) cable connecting a log barge to a 5443 kg (6 ton) anchor near Craig. The adult-sized animal was entangled for several days with cable caught in its mouth and multiple tight wraps around its body. Responders cut the cable and the whale slowly swam away, apparently free of the gear. However, the whale sustained significant soft tissue injuries and its fate is unknown (NOAA Alaska Region unpublished data).

The second incident occurred on August 27 in Holkham Bay at the mouth of Endicott Arm when a humpback whale (believed to be a sub-adult based on body size) became entangled in a 22 mm (7/8 in) anchor chain from the commercial tour vessel *Wilderness Explorer*. The chain was caught in the whale's mouth and wrapped around its body, causing significant soft tissue injuries. After several hours, responders cut the chain. The whale remained at the surface for some time before submerging. A whale thought to be the freed animal was spotted ~400 m (~0.25 mi) away but it was not possible to confirm this was the same individual and the whale's fate is unknown (NOAA Alaska Region unpublished data).

At least three additional entanglements in SEAK involved free-swimming humpback whales reported to be wrapped in and/or trailing gear. On January 21, a whale was observed in Port Frederick trailing a single orange buoy which submerged when it dove. On July 21, a whale was reported in Frederick Sound with multiple wraps of heavy line around its head and body and trailing floats and line. On October 11, a whale was reported in Thorne Bay Arm entangled in a red buoy. The next day, a similar report was received from this general area and may have been the same animal. No further sightings were reported of any of these entangled whales and their fates are unknown (NOAA Alaska Region unpublished data).

Elsewhere in Alaska, one humpback whale and two whales that may have been humpbacks were reported entangled in 2017 (NOAA Alaska Region unpublished data).

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Appendix A

Annual sighting histories of ‘regularly sighted’ humpback whales in Glacier Bay-Icy Strait (n = 66) are shown in Table A-1 below.

Table A-1. Annual sighting histories of 'regularly sighted' humpback whales in Glacier Bay-Icy Strait (n = 66). Years when a whale was documented between June 1 - August 31 in the GB-IS study area are indicated with a "✓". Years when a whale was not documented between June 1 - August 31 in the GB-IS study area or elsewhere in SEAK are indicated with an "X" (also highlighted in yellow) and the whale's age, if known (unk = unknown). Years when a whale was documented either a) in GB-IS but only outside the June 1 – August 31 standard monitoring period or b) elsewhere in SEAK are indicated with a two-letter code (also in gray; see key below table). All sightings are from the GBNPP humpback whale monitoring program unless otherwise noted in the Comments field (AWF = Alaska Whale Foundation, NOAA = National Oceanic and Atmospheric Administration, or the photographer's name if not associated with a research group).

ID#	Sex	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Comments
117	M	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	–
118	M	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	–
155	F	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	–
157	M	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	IS[a]	5/9/17 in IS[a]
159	M	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	–
161	F	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X (age unk)	✓	✓	✓	–
166	M	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X (age unk)	X (age unk)	X (age unk)	–
186	M	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X (age 34)	X (age 35)	–
219	F	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X (age unk)	X (age unk)	✓	–
221	M	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	–
232	F	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X (age unk)	–
235	F	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X (age unk)	FS[a]	X (age unk)	8/5/16 in FS[a] (AWF)
250	F	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X (age unk)	✓	IS[a]	5/19/17 in IS[a]
351	M	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	–
352	M	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	–
465	M*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X (age unk)	–
516	M	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	LC[a]	X (age 43)	4/25/16 in LC[a] (K. Keller)
535	F	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X (age unk)	X (age unk)	X (age unk)	–
573	F	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X (age unk)	X (age unk)	–
581	F	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X (age unk)	X (age unk)	X (age unk)	X (age unk)	–

[a] Sighting locations when a whale was documented either a) in GB-IS but only outside the June 1 – August 31 standard monitoring period or b) elsewhere in SEAK: CS = Chatham Strait; FS = Frederick Sound; GB = Glacier Bay; IS = Icy Strait; LC = Lynn Canal.

Table A-1. Annual sighting histories of 'regularly sighted' humpback whales in Glacier Bay-Icy Strait (n = 66). Years when a whale was documented between June 1 - August 31 in the GB-IS study area are indicated with a "✓". Years when a whale was not documented between June 1 - August 31 in the GB-IS study area or elsewhere in SEAK are indicated with an "X" (also highlighted in yellow) and the whale's age, if known (unk = unknown). Years when a whale was documented either a) in GB-IS but only outside the June 1 – August 31 standard monitoring period or b) elsewhere in SEAK are indicated with a two-letter code (also in gray; see key below table). All sightings are from the GBNPP humpback whale monitoring program unless otherwise noted in the Comments field (AWF = Alaska Whale Foundation, NOAA = National Oceanic and Atmospheric Administration, or the photographer's name if not associated with a research group).

ID#	Sex	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Comments
587	F	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X (age unk)	–
616	M	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X (age unk)	✓	IS[a]	8/2/17 in IS[a] (NOAA), 9/5/17 in IS[a] (M. Greenfelder/Happywhale)
875	M	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	–
937	M	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	CS[a]	7/24/17 and 7/28/17 in CS[a] (NOAA)
1012	M	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	–
1014	F	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X (age 28)	–
1018	F	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X (age unk)	X (age unk)	–
1019	F	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	–
1042	F	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X (age 29)	X (age 30)	–
1046	F	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	–
1063	M	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X (age unk)	–
1065	M*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	–
1082	M*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	–
1083	M	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	–
1088	F	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	–
1233	F	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X (age 31)	–
1244	M	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	–
1246	F	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X (age unk)	X (age unk)	–
1293	F	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	–
1298	F	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X (age 25)	–
1299	M	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	–

[a] Sighting locations when a whale was documented either a) in GB-IS but only outside the June 1 – August 31 standard monitoring period or b) elsewhere in SEAK: CS = Chatham Strait; FS = Frederick Sound; GB = Glacier Bay; IS = Icy Strait; LC = Lynn Canal.

Table A-1. Annual sighting histories of ‘regularly sighted’ humpback whales in Glacier Bay-Icy Strait (n = 66). Years when a whale was documented between June 1 - August 31 in the GB-IS study area are indicated with a “✓”. Years when a whale was not documented between June 1 - August 31 in the GB-IS study area or elsewhere in SEAK are indicated with an “X” (also highlighted in yellow) and the whale’s age, if known (unk = unknown). Years when a whale was documented either a) in GB-IS but only outside the June 1 – August 31 standard monitoring period or b) elsewhere in SEAK are indicated with a two-letter code (also in gray; see key below table). All sightings are from the GBNPP humpback whale monitoring program unless otherwise noted in the Comments field (AWF = Alaska Whale Foundation, NOAA = National Oceanic and Atmospheric Administration, or the photographer’s name if not associated with a research group).

ID#	Sex	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Comments
1302	F	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	–
1306	U	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X (age 22)	✓	✓	X (age 25)	–
1313	U	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	–
1421	F	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X (age 17)	GB[a]	X (age 19)	CS[a]	10/5/15 in GB[a], 7/27/17 in CS[a] (NOAA)
1432	F	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	–
1438	M	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	–
1439	M	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X (age 19)	–
1461	M	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	–
1474	M	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	–
1485	M	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	–
1486	F	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	–
1489	M	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	–
1505	U*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	–
1532	U	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X (age unk)	✓	–
1652	M	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	–
1659	M	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	–
1807	M	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	–
1808	U*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	–
1815	M	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X (age unk)	✓	X (age unk)	–
1816	M	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	–
1817	M	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X (age unk)	✓	X (age unk)	CS[a]	7/24/17 in CS[a] (NOAA)
1836	U	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	–

[a] Sighting locations when a whale was documented either a) in GB-IS but only outside the June 1 – August 31 standard monitoring period or b) elsewhere in SEAK: CS = Chatham Strait; FS = Frederick Sound; GB = Glacier Bay; IS = Icy Strait; LC = Lynn Canal.

Table A-1. Annual sighting histories of 'regularly sighted' humpback whales in Glacier Bay-Icy Strait (n = 66). Years when a whale was documented between June 1 - August 31 in the GB-IS study area are indicated with a "✓". Years when a whale was not documented between June 1 - August 31 in the GB-IS study area or elsewhere in SEAK are indicated with an "X" (also highlighted in yellow) and the whale's age, if known (unk = unknown). Years when a whale was documented either a) in GB-IS but only outside the June 1 – August 31 standard monitoring period or b) elsewhere in SEAK are indicated with a two-letter code (also in gray; see key below table). All sightings are from the GBNPP humpback whale monitoring program unless otherwise noted in the Comments field (AWF = Alaska Whale Foundation, NOAA = National Oceanic and Atmospheric Administration, or the photographer's name if not associated with a research group).

ID#	Sex	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Comments
1840	M	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	–
1896	F	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	–
1900	M	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	–

[a] Sighting locations when a whale was documented either a) in GB-IS but only outside the June 1 – August 31 standard monitoring period or b) elsewhere in SEAK: CS = Chatham Strait; FS = Frederick Sound; GB = Glacier Bay; IS = Icy Strait; LC = Lynn Canal.

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